Applications and Priorities for RNP Instrument Approach Procedure Implementation

Report by Performance-based Operations Aviation Rulemaking Committee

February 2005

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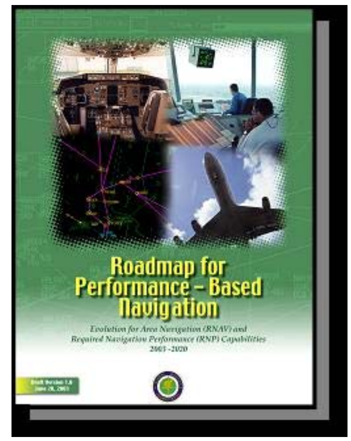
1. Introduction and Background

Performance-Based Navigation



In July, 2003, the Federal Aviation Administration (FAA) published the *Roadmap for Performance-Based Navigation*, which was created in collaboration with the aviation community through the Terminal Area Operations and Aviation Rulemaking Committee (TAOARC), now known as the Performance-Based Aviation Rulemaking Committee (PARC). The Roadmap described the FAA's overall strategy to move the aviation system to a performance-based system for navigation, which will produce the highest levels of safety and security and will increase access, reduce delays, and improve the efficiency of the National Airspace System. It established high level goals and plans for near-, mid- and far-term implementation of performance-based navigation in the en route, oceanic, terminal, and approach phases of flight.

Performance-based navigation is defined as navigation along a route, in a procedure or in airspace within which the aircraft operating must comply with specified performance requirements. This is a fundamental shift from a navigation paradigm that specifies equipment types and technologies. A key component of establishing a performance-based navigation system is the use of area navigation (RNAV) and Required Navigation Performance (RNP), which define specified levels of performance, functionality, and capability as agreed-upon navigation standards. These standards facilitate more efficient airspace and procedure design, which collectively result in improved safety, access, capacity, predictability, operational efficiency, and environmental impacts. Specifically, performance-based navigation will:

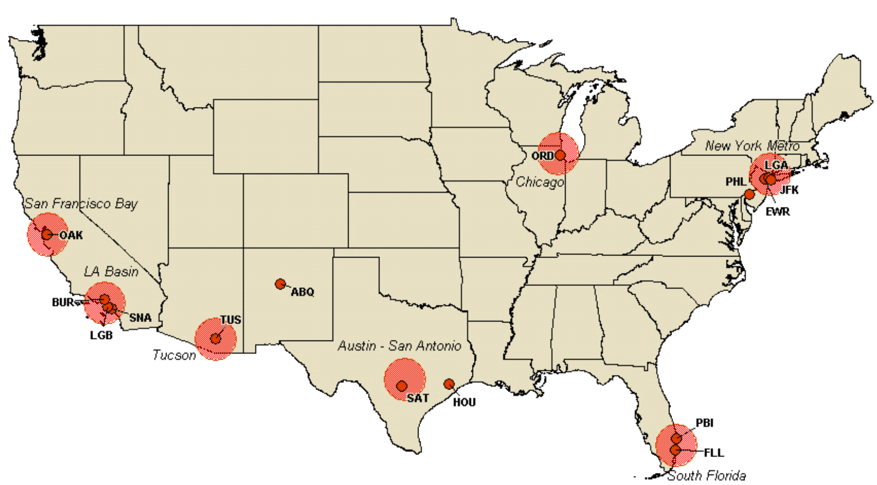
- Increase safety through continuous descent procedures that reduce the risk of controlled flight into terrain (CFIT) and loss of control. Predefined RNAV and RNP procedures enhance confidence and consistency and reduce the risk of communication errors.
- Improve airport and airspace access in all weather conditions and the ability to meet environmental and obstacle clearance constraints through the application of optimized RNAV-based flight tracks. The result will be reduced lateral separation criteria and more accurate path keeping.
- Enhance reliability, repeatability and predictability of operations, leading to increased throughput. More precise arrival, approach and departure procedures will reduce dispersion and facilitate smoother traffic flows.

- Increase schedule reliability through more consistent access and throughput in all weather conditions.
- Reduce delays at airports and in certain dense airspace through the application of new parallel routes; newly enabled ingress/egress points around busy terminal areas; improved flight re-routing capabilities, making better use of closely spaced procedures and airspace; and de-conflicting adjacent airport flows.
- Increase efficiency through less circuitous routes and optimized airspace, especially in lower flight altitude stratums.
- Enable flexible routes such as wind-optimal and great circle routes when beneficial.
- Promote design and use of environmentally beneficial arrival and departure procedures that allow the aircraft systems (i.e., the FMS) to manage flight performance (climb, descent, engine performance, etc.). Benefits include reduced fuel emissions and environmentally-tailored noise footprints.

Meeting Needs of Future Air Traffic Growth

The growth of air traffic in the National Airspace System has been increasing steadily for the past few years and is expected to continue for the foreseeable future. The FAA is working to address the impact of traffic growth by increasing the system capacity and efficiency of the NAS while simultaneously maintaining or improving safety, environmental impacts, and user access to the NAS. Meanwhile, the aviation industry and FAA are all operating within a difficult financial state, in which tough decisions must be made about how to invest to handle cost-effectively the growing demands on the system.

An FAA study completed in 2004 by the Future Airport Capacity Task Force (FACT) investigated two fundamental questions: (1) Which of the major airports in the NAS will be able to meet future demand, which will not, and why; and (2) Beyond the top 35 major airports, will there be socio-economic growth in other geographic areas with airports unable to accommodate demand for air transportation? According to the study's findings, published in "Capacity Needs in the National Airspace System," not only will additional air traffic growth in the future strain the system capacity, but even today there are areas where additional capacity is needed. The study showed that approximately 5 percent of the nearly 300 airports analyzed will require additional capacity by either 2013 or 2020. The FACT identified five major airports as having **immediate**



capacity needs: ATL, ORD, EWR, LGA, and PHL. The FACT also identified the following airports as having future capacity needs in the 2013 timeframe, even assuming the NAS improvements contained in the FAA's Operational Evolution Plan (OEP):

- Oakland, CA (OAK)
- Burbank, CA (BUR)
- Long Beach, CA (LGB)
- John Wayne Orange County, CA (SNA)
- Tucson, AZ (TUS)
- Albuquerque, NM (ABQ)
- San Antonio, TX (SAT)
- Houston Hobby (HOU)
- Chicago O'Hare (ORD)
- New York's LaGuardia (LGA)
- New York's Kennedy (JFK)
- Newark, NJ (EWR)
- Philadelphia, PA (PHL)
- Palm Beach, FL (PBI)
- Ft. Lauderdale, FL (FLL)

In addition, the following metropolitan areas were identified as needing additional capacity by 2013: San Francisco Bay, Los Angeles Basin, Tucson, Austin-San Antonio, Chicago, New York Metro, and South Florida.

In addition to local capacity and delay issues experienced at our nation's airports, several of the major airports in the NAS are considered "pacing airports" because of the impact they have on overall NAS performance on a daily basis. Examples of "pacing airports" are the following:

- Hartsfield-Jackson Atlanta International (ATL)
- Boston Logan International (BOS)
- Chicago O'Hare International (ORD)
- Newark Liberty International (EWR)
- New York Kennedy International (JFK)
- New York LaGuardia (LGA)
- Philadelphia International (PHL)
- San Francisco International (SFO)

Because of the large numbers of daily flights that go through these airports, delays at any of these airports quickly and dramatically cause a ripple effect on large regions (and sometimes all) of the NAS. Likewise, improvements in capacity, throughput, and efficiency at any of these airports can have a substantial positive impact on the entire NAS. For these reasons, these airports are immediately considered as important candidates for any proposed terminal and airport improvements such as performance-based navigation procedures.

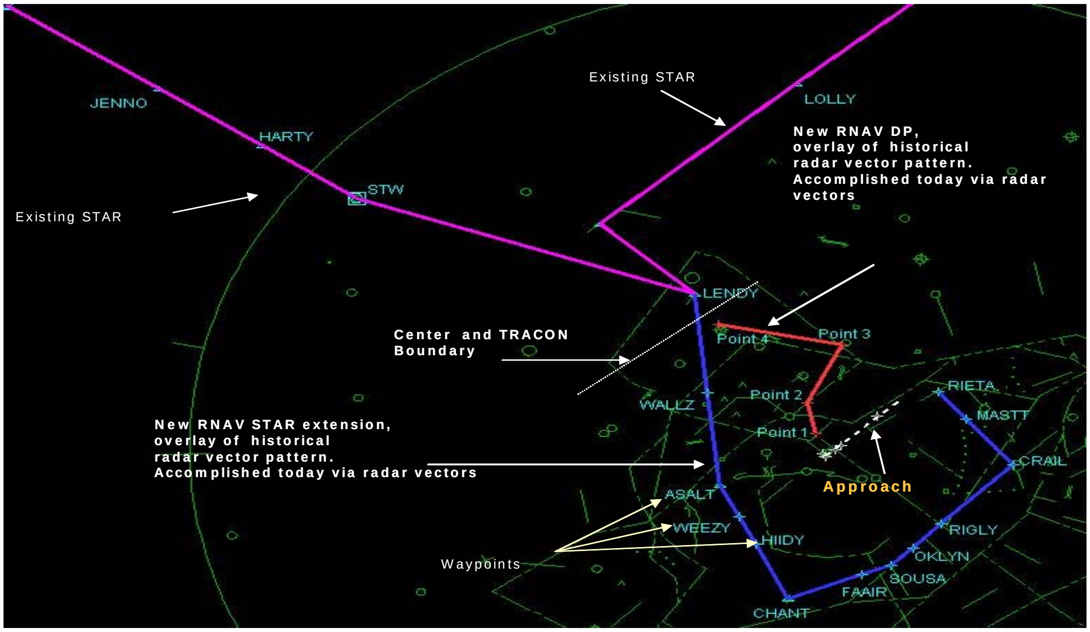
Plans are in place and efforts underway for infrastructure improvements at a number of these airports, particularly new runway construction projects, which are critical to reducing the system capacity constraints and increasing efficiency. However, the projected problems identified by the FACT already take into account most of the improvements currently being planned. If any of the planned improvements do not occur, the number of airports experiencing capacity shortages will grow sharply. Clearly, there is a need for additional airport and terminal area improvements to help resolve capacity and efficiency issues, while maintaining or improving current levels of safety, environmental impacts, and user access. The long lead times required to bring a new runway into use, equip aircraft with new technologies, or implement a change in NAS automation, make it imperative that we maximize our efforts to improve NAS capacity and efficiency through procedural changes using existing ground and aircraft capabilities and equipment. The FACT states, "In addition to new runways and airports, procedures, technologies, and policy options should be explored."

A critical element to optimizing procedures based on existing equipage is the FAA's implementation of performance-based navigation. Performance-based navigation will enable the needed operational improvements by leveraging current and evolving capabilities in the near-term that can be expanded to address the future needs of NAS stakeholders and service providers.

Performance-based Navigation in Terminal and Approach Operations

Performance-based navigation will improve airport and terminal area performance in a number of ways, including establishment of RNAV Standard Terminal Arrival (STAR) and Standard Instrument Departure (SID) procedures, as well as RNP and RNAV approach paths. Using performance-based navigation results in more accurate and predictable flight paths, and eliminates the reliance on the location of ground-based navigation aids. RNAV SIDs and STARs enable new routings, consistent path definition, improved navigation accuracy and flight guidance. These procedures facilitate a variety of possible improvements, such as the ability to increase the number of ingress and egress points between terminal and en route airspace, to increase capacity and throughput, minimize time and/or distance flown, and even to reduce noise and emissions.

The graphic shows the integration of conventional STARs (pink routes), connected to a new RNAV STAR extension (blue), and followed by the approach to runway 22 L. For departures, a new RNAV SID (also known as a departure procedure or DP) is intended for departure improvements as well. The benefits of performance-based procedures can be maximized when the procedures are connected, removing the need for open-ended instructions via controller vectoring. The advantage of RNP approaches in this example is to connect the RNAV STAR extension, shown below to end at RIETA, with the approach through a curved segment.



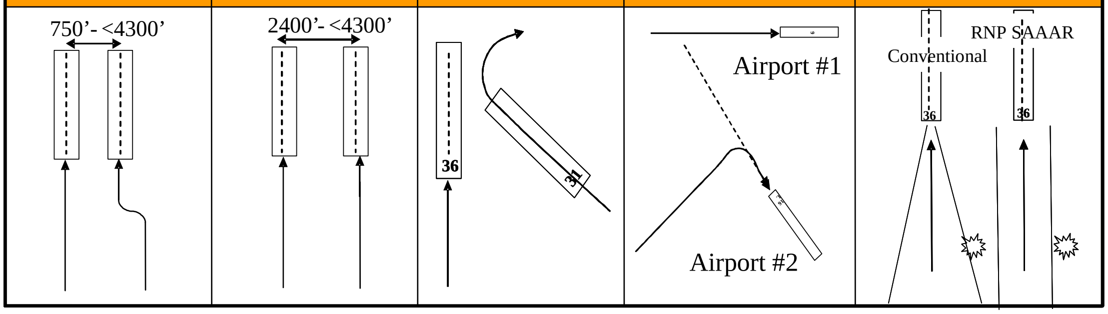
Procedures for RNAV STARs, SIDs, and approaches are currently being developed by the FAA and aviation industry in as many locations as possible around the NAS. This report focuses on the applications and priorities for implementing beneficial RNP approaches in the NAS. Reports on the other aspects of terminal area performance-based implementation such as RNAV STARs, SIDs, and approaches will be published separately.

2. Applications and Priorities for RNP Approaches

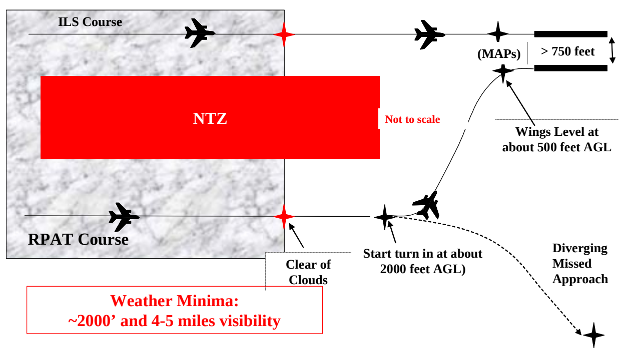
For certain airports, opportunities exist for benefits based on lower RNP values, elimination of the secondary obstruction clearance area, performance-based vertical obstruction clearance surfaces, and path segments that are not straight in and straight out. These are the features of RNP SAAAR approaches that operators have requested and the FAA has granted. Operators will apply these procedures where needed to avoid obstacles or airspace along the approach and/or missed-approach segments. Because these approach features apply to certain operations and not to others, their application is limited to those locations where aircraft capabilities exist and where benefits can be realized. These will provide opportunities for any operator that satisfies the special aircraft and aircrew authorization required (SAAAR) for use of these procedures.

Applications of RNP SAAAR Approaches

Parallel with Visual Transition	Parallel without Transition	Simultaneous Converging	De-confliction of Adjacent Airports	Runway Access and Risk Management

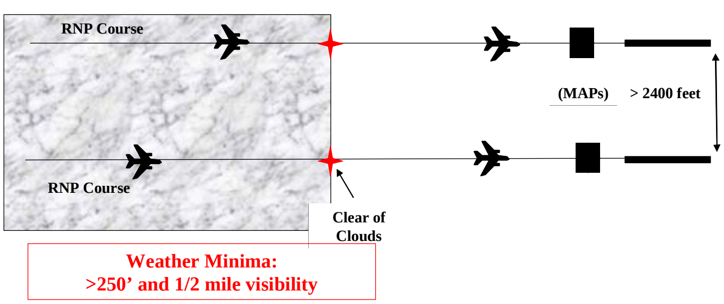


The applications for RNP SAAAR instrument approaches are closely-spaced parallel approaches, converging approaches, de-confliction of operations between adjacent airports, and single runway access. The majority of these applications pertain to busy terminal areas that need improved capacity during high traffic demand periods. Therefore the intended benefits are to deliver higher capacity and improved arrival efficiency, without disrupting departures and other aspects of operations (e.g., mixed fleets and equipage).



Parallel Approaches

RNP SAAAR enables improved capacity and arrival efficiency through parallel approaches to closely-spaced runways at busy airports during IMC. This is accomplished using narrow, linear approach segments and the RNP Parallel Approach Transition (RPAT) or the RNP Parallel Approach with no transition (RPA). Both of these procedure types may use a range of RNP values (depending on runway centerline separation). RPAT, and perhaps also RPA, support conventional operations since they may involve ILS approach operations to one of parallel runways. For maximum arrival efficiency during very busy periods of traffic demand, RPAT or RPA may be applied to triple or quad parallel runways, or may be used in combination with a converging runway.

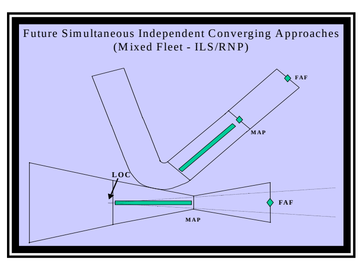


The RPA application has particular application for airports in need of closely-spaced parallel approaches to low minimums (theoretically as low as 250'). RPA is also of particular benefit to sites with environmental constraints unable to place new routes offset from existing approach courses. RPA application is limited, however, to airports with runway centerline spacing between 2400-4299' (2400' being the best case scenario in using RNP-0.1, and a route width of 2xRNP to both parallel routes.) Sites with parallel runway centerline spacing between 2400 and 4299' are listed in the table and would be potential candidates for RPA application.

Site	Airport Name	Runway Pairs	Spacing	Usage Date
ATL	Atlanta-Hartsfield	9R/10	4,200	6/8/2006
CLT	Charlotte/Douglas	10/10R	3,700	TBD
CMH	Columbus	10L/10R	2,800	In Use
DAL	Dallas-Love Field	13L/13R	3,000	In Use
DEN	Denver	16L/16R	2,600	In Use
DFW	Dallas-Ft. Worth	17L/17C	3,000	In Use
DTW	Detroit	22R/22L; 21R/21L	3,800; 2,700	In Use
FLL	Fort Lauderdale	9L/9R	4,000	TBD
HRL	Harlingen, TX	17L/17R	3,200	In Use
IND	Indianapolis	5C/5R	3,500	2008
JAN	Jackson, MS	16L/16R	3,500	In Use
JFK	NY - Kennedy	4L/4R	3,000	In Use
LGB	Long Beach	7L/7R	3,200	In Use
LIT	Little Rock	4L/4R	4,000	In Use
MEM	Memphis	18C/18R	3,400	In Use
MKE	Milwaukee	7L/7R	3,600	In Use
MSP	Minneapolis	12L/12R	3,380	In Use
PDX	Portland	10L/10R	3,100	In Use
PHX	Phoenix	8/7L	3,565	In Use
RDU	Raleigh-Durham	5L/5R	3,400	In Use
SEA	Seattle-Tacoma	16L/16R (future)	2,500	11/20/2008
SLC	Salt Lake City	17/16L	3,200	In Use
STL	St. Louis	12R/12	2,500	2006
TUS	Tucson	11L/11	2,700	2010

Converging Approaches

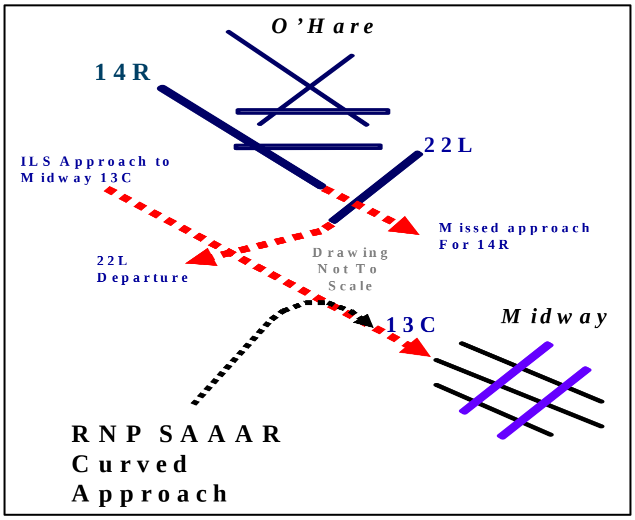
In a similar way to the parallel runway applications, RNP SAAAR enables improved capacity and arrival efficiency to converging runways. Simultaneous Converging Instrument Approaches (SCIAs) are used today at several airports to minimums such as 1000' and 3 miles visibility, or in some cases slightly lower than that. RNP SAAAR application to one or both runways in this scenario would enable lower weather minimums than we have today, since we can apply early, guided turns on the missed approach and reduce visibility requirements.



An initial analysis was performed on four sites that currently use SCIAs today, as evidenced by existing instrument approach plates: Dallas-Fort Worth (DFW), Washington Dulles (IAD), Philadelphia (PHL) and Pittsburgh (PIT). In addition, analysis was performed on three sites: Charlotte (CLT), Chicago's O'Hare (ORD), and Minneapolis (MSP) that either currently or in the future will use converging runways simultaneously, but only in VMC. The initial analysis was a parametric study of benefits (without analysis of any particular approach or runway design) assuming minima could be lowered by anywhere from 100 to 400'. While RNP SAAAR approaches are not intended to achieve ILS minima, a 400' reduction in minima may be possible for some approaches with particularly high minima.

Site	Current SCIA Minimum	Proposed SAAAR Runway	Approximate Capacity Increase Over IMC Baseline
CLT	1000'/3	23	minimal
DFW	1000'/3	13R/31R	33%
IAD	1000'/3	12	50%
MSP*	1000'/3	35 (new runway)	28%
ORD	1000'/3	4R	14%
PHL	700'/2	9R	30%
PIT	900'/2	32	11%

Adjacent Airport Operations



De-confliction of operations at adjacent airports is accomplished through airspace efficiency, more specifically achieved through the implementation of curved final approach segments and tailored missed approaches. The classic example of this problem is the proximity of ORD and MDW airports. When Plan B is in use at ORD, with 1000' ceiling and 3 miles visibility or better, departures use 27L and 22L, and arrivals use 22R and 14R. If MDW uses the 13C ILS at the same time, ORD 22L departures conflict with MDW 13C approaches, so ORD departures are changed to 14L which crosses 22R and reduces the departure rate. As the weather degrades, simultaneous 14's are used for arrivals at O'Hare when the ceiling is 800' and/or visibility is 2 miles. In this case, ORD 14R missed approach segments conflict with the MDW 13C approaches. This results in staggering 14R and 14L arrivals (to prevent simultaneous go-arounds) into ORD, reducing the arrival rate.

An RNP SAAAR Curved Approach to 13C would eliminate these conflicts and avoid a total of approximately $8M incurred last year for *additional* minutes of delay and *additional* flight cancellations at these two airports. This is detailed in the table below showing the additional minutes of delay per year and additional cancellations per year at both MDW and ORD.

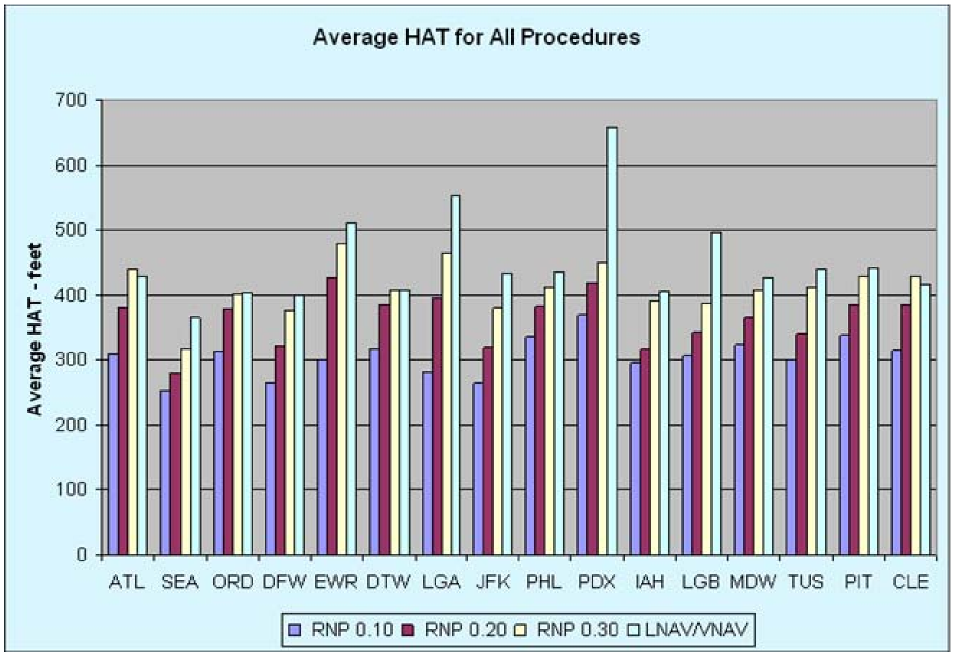
	Delays (minutes per year)		Cancellations (per year)		Cost (per year)
Airport	Departures	Arrivals	Departures	Arrivals	
MDW	6,744	3,597	5 more	1 more	$500,000
ORD	53,988	61,449	149 more	84 more	$7,400,000

Conflicts currently occur also between New York's Kennedy Airport (JFK) and LaGuardia Airport (LGA) when JFK is under IMC and is operating ILS approaches into runway 13L (i.e., when minimums are less than 800/2 and the winds dictate runway 13L) This straight-in ILS approach conflicts with the approach path into runway 4 at LGA, and the missed approach for runway 22. This conflict was shown to occur during 229 fifteen-minute time periods in 2003, or roughly 2.4 aggregate days. This resulted in over 300 more flights cancelled for JFK and LGA combined, in addition to over 20,000 additional minutes of delay, incurring a loss of an *additional* $3.7M for operators at these two airports last year.

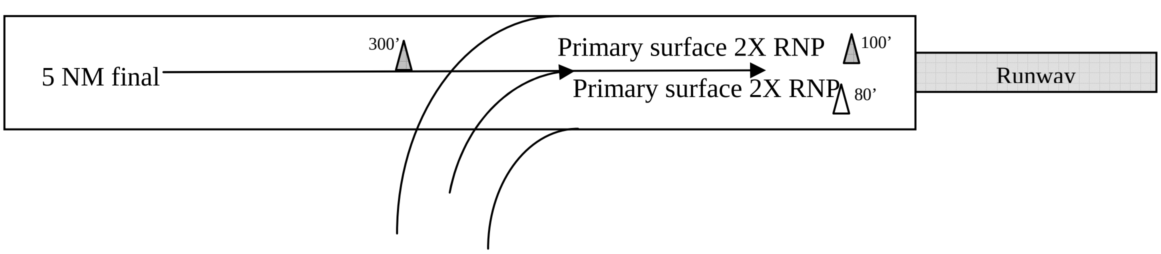
	Delays (minutes per year)		Cancellations (per year)		Cost (per year)
Airport	Departures	Arrivals	Departures	Arrivals	
JFK	5,105	1,953	34 more	46 more	$1,000,000
LGA	10,925	10,051	153 more	151 more	$2,700,000

Access and Safety

Single runway approach operations are improved through RNP SAAAR, in particular at runways with obstructions in the final approach segment (not too close in) and/or along the missed approach segment. Improved safety and access are accomplished through constant-descent approaches and reduced obstruction clearance surfaces, with curved segments where needed. The following chart shows comparative access minimums modeled at 16 candidate airports. The comparison shows an average "height above threshold" (HAT) for straight-in approaches to all runways at that airport, modeled based on RNP SAAAR approach criteria versus the existing RNAV (LNAV/VNAV) approach criteria[1,2]. For RNP SAAAR we show modeled results for RNP-0.1, 0.2, and 0.3 for comparative purposes.



In addition to single runway, straight-in approach benefits, there are benefits of allowing curved legs anywhere along the approach including the final segment inside the final approach fix (approximately 5 NM from the runway), and in the early portion of the missed approach. Particularly in mountainous terrain, many runways have obstructions in the final approach area (not too close in) or in the missed approach area, that could be mitigated by curved final or missed approach segments. The graphic below shows this effect (see the 300' peak on the extended runway centerline that is excluded by applying segments that are curved in or out). Modeling results show that several hundred runways ends benefit from curved final segments, with minimums reduced up to several hundred feet in some cases.



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[1] FAA Notice 8000.287, *Criteria for Development and Approval of RNP SAAAR Special Instrument Approach Procedures*, 2004.

[2] FAA Order 8260.38A *Civil Utilization of GPS*, and FAA Order 8260.48 *Area Navigation (RNAV) Approach Construction Criteria*.

A complete list of airports requiring special authorization for access is found in CFR 121.445 and is the following: ASE, AVL, BGM, BKW, BLF, BTM, BTV, CBE, COD, CRW, DRO, EAT, EEN, EGE, ELM, FLG, GUC, HDN, HSP, HTS, IFP, JAC, LEB, LMT, MSO, OTH, RIL, ROA, SHD, SLK, SUN*, TEX, TVL, WYS (see appendix A for the names/locations of these airports.) These and other airports provided a good set of candidates to examine for single runway access and safety benefits of RNP SAAAR. The needs for improved access and safety at these types of airports vary, and are among those listed below:

- Lack of Radar Coverage – Mountainous areas in western U.S.
- High Density Air Traffic Environment – Chicago Terminal Area (ORD/MDW)
- Approach/Missed Approach Terrain Constrained – Mountainous areas
- Lack of Navigation Aides and limited instrument approach procedures – Less busy and remote airports
- Extreme Instrument Procedure Vertical path constraints leading to energy management and pilot task load issues – Airports with non-precision approach procedures where the missed approach point is at the runway end, requiring steep final descent to land
- Terminal Area Weather patterns – Winds, ceilings, and icing presenting particular challenges at some airports
- Night Operations over Unlit Terrain - lack of situational awareness and high resulting high workload could be mitigated by guidance and containment-based RNP SAAAR operations.

All of the characteristics listed above affect both the operational risk management task and available airport access. The two operational concepts are inseparable from a user standpoint. All of the issues listed may be addressed by RNP SAAAR procedure design.

Airports exhibiting the needs listed above come in a multitude of sizes both from an operational (e.g., airspace) and geographic sense. Some examples include the following airports and runways:

- Aspen's runway 15 instrument approach is a VOR/DME to a relatively high minimum descent altitude due to the nearby terrain. This terrain constrains access and presents risk due to energy management issues in executing a steeper-than-normal vertical descent path in the final approach segment, and steep climb gradient for the missed approach. Applying RNP SAAAR procedure design criteria, the new approach would mitigate the operational risk. The final segment would be flown on a constant (3 to 3.5 degree) glide path and the missed approach path would be guided – avoiding hazardous terrain. A stabilized approach with improved minima will be beneficial and will be a risk mitigation factor.
- San Francisco International airport (SFO) 10L/10R where the RNAV (GPS) approach ceiling minimum is rather high at 940’. With an RNP SAAAR approach (overlaying the RNAV approach), the minima could be reduced to a theoretical height of 250’.
- Eagle County Regional Airport (EGE, see photo), which serves Vail, Colorado, is an example of this type of application as it is located in a mountainous region. An

RNP SAAAR procedure could be implemented at EGE that would help to mitigate risk by applying an accurate and repeatable vertical path, improving the pilot familiarity with the procedure even if the pilot does not fly to EGE often.

- Midway airport is adversely affected by both ORD traffic and lack of instrument approach procedures for all useful runway ends. In the case of 22L, the existing procedure requires an initial flight path on the 31C Localizer to a visual "break off' point followed by a circle maneuver to land on 22L. The weather required is basic VFR, therefore the runway is not accessible during instrument conditions. This circling procedure presents a challenging pilot task in certain (common) airport weather conditions. A dedicated 22L instrument approach applying RNP SAAAR would increase airport capacity during specific wind / weather conditions and mitigate the operational risk associated with a circling maneuver.

Early "Special" Implementation, Proof of Concept and Validation of Criteria
In 2004, the FAA and the aviation community through the Performance-based Aviation Rulemaking Committee (PARC) identified a set of first applications at airports for special RNP instrument approach implementation. The first phase of site selection leveraged efforts by lead operators to develop and use *special* procedures at a few sites in 2004 and 2005 to demonstrate the concept of RNP SAAAR and to exercise and validate the criteria developed for these procedures.

In late 2003, the aviation industry through the PARC generated a non-prioritized list of approximately 60 runway ends that was based on suggestions by the potential participants in RNP SAAAR procedures. These participants included approximately ten airlines and business aircraft operators. The selection for the first phase (for the first few sites) was focused on low risk, high success, operator readiness, alignment with the *Roadmap for Performance-based Navigation,* and an ability to demonstrate the features of RNP SAAAR. The FAA and the aviation community through the PARC developed prioritization criteria for prioritizing the list of runway projects submitted by the operators.

The criteria were as follows:

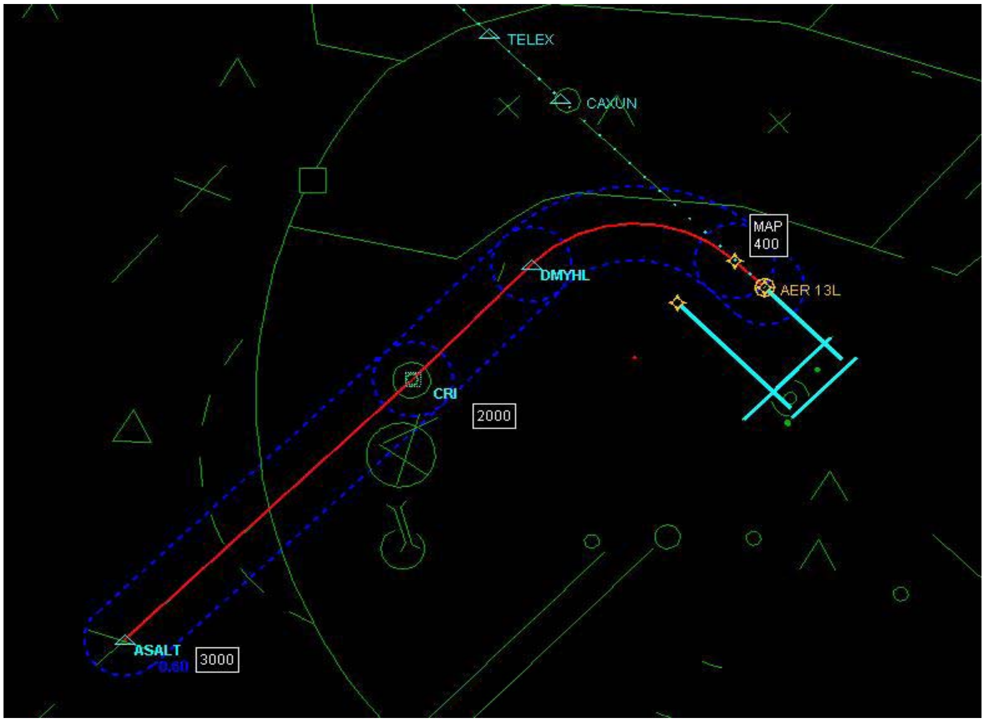
- Benefits
  - Access (minima, arrival rate)
  - Airspace/Traffic De-confliction (delays/holds avoided)
  - Efficiency (flight or taxi time/distance)
  - Safety (elimination of circle to land and/or night visual approach; risk mitigation for runways without vertically-guided approaches)
  - Environmental (consistent ground tracks)
- Operator “readiness”
  - Aircraft equipage and qualification
  - Operational approval
  - Crew training
- Site “readiness”
  - Regional Airspace Procedures Team (RAPT) and Local (Center, Terminal, Airport) acceptance
  - Mixed equipage – capable versus non-capable operations are managed
  - Ability and willingness to utilize the procedures
  - Experience with RNAV or RNP at the site is a consideration
- SAAAR attribute usage and site suitability
  - Ability to demonstrate SAAAR attributes
  - Parallel/converging runway applications are of particular interest
- Proof of Concept
  - TERPS usage and design validation
  - Flyability and repeatable ground tracks
  - ATC and operator acceptance

As stated earlier, the prioritization for these 2004-05 sites was accomplished in February 2004 by a joint FAA/industry group under the PARC. The first five airports at which special RNP instrument approach procedures are being implemented are listed below including the lead operator for each site. The table identifies the lead operator, the features of the RNP criteria being used and the expected benefit. There are a total of nine RNP SAAAR procedures being implemented at these five sites.

Airport	Lead Operator	Criteria Element	Expected Benefits
DCA	Alaska	Curved path (RF) Reduced RNP No secondary “buffer” Vertical surface	Improves access, better safety through 3-D guidance to the runway, avoids protected areas around Pentagon and Capitol
JFK	JetBlue	Curved path (RF) No secondary	De-conflicts traffic with LaGuardia, improves access to preferred runway 13s during IMC, guidance to the runway
IAH	Continental	Curved path (RF) in missed approach Reduced RNP No secondary	Lowers minima during ILS outage, mitigates controlling obstacle, increases use of departure runways
PDX	Horizon	Curved path (RF) Reduced RNP No secondary	Improves access to preferred runway, reduces taxi time
PSP	Alaska	Curved path (RF) Reduced RNP No secondary Vertical surface	Safety benefit of a stabilized 3-degree glide path, improved safety with a straight-in final, reduces miles flown significantly

Lead operators (including Alaska Airlines, Continental Airlines, Horizon Air, and JetBlue Airline) have been working with the FAA at the five above airports to develop preliminary procedures expected to begin operating as “specials” in 2004 and 2005. This strategy is providing an opportunity for eligible aircraft and operators to obtain initial authorizations and gain company experience flying RNP and curved segments through the “specials” implementation process.

The five sites have existing problems that are addressed by RNP SAAAR and are good candidates for demonstrating RNP applications. For example, curved approaches into JFK's 13L and 13R runways provide instrument guidance to the runway, and lower minimums by several hundred feet without conflicting with arrivals into nearby LaGuardia. This de-confliction scenario was described in an earlier section of this report.



RNP SAAAR Approach JFK 13L

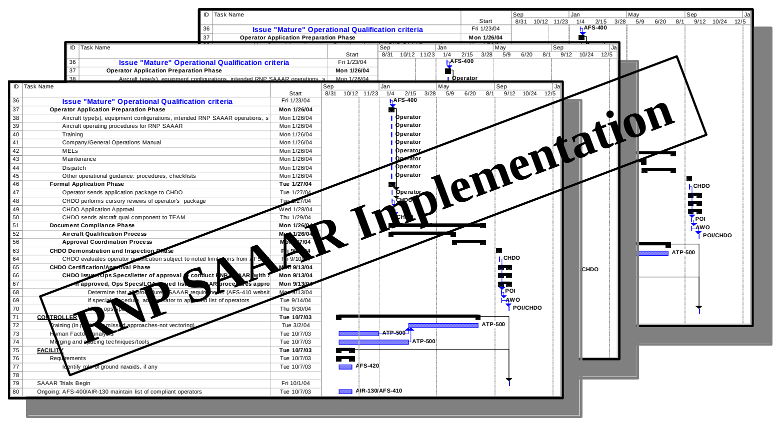
The PARC also determined a next set of 4 airports at which additional special RNP instrument approach procedures to be implemented. The intent for this next set was similar to that of first: To continue to gain company experience, lessons learned and to continue to validate the RNP criteria. These sites were selected for the next set of procedures scheduled for implementation, as shown below.

Airport	Lead Carrier	Criteria Element	Expected Benefits
EWR	Continental	Curved path (RF) Reduced RNP No secondary "buffer" Vertical surface	Improves access to runway 29, better safety through 3-D guidance to the runway. RNP 4R/22L de-conflicts traffic with LGA, improves access to preferred runways, provides guidance to the runway.
MDW	FAA	Curved path (RF) in missed approach Reduced RNP No secondary	Lowers minima during ILS outages, mitigates controlling obstacle, increases use of arrival and departure runways
TUS	Alaska	Curved path (RF) Reduced RNP No secondary	Improves access to preferred runway, reduces taxi time
PIT or PHL	US Airways	Curved path (RF) Reduced RNP No secondary	Safety benefit of stabilized 3-degree glide path, improved safety with a straight-in final, reduces miles flown

In addition to the nine airports being pursued for RNP SAAAR special procedures, the FAA and industry are implementing RPAT as special procedures at three airports in 2004-2005.

Airport	Lead Carrier	Procedure	Expected Benefits
SFO	Alaska	RPAT 28R	Improved capacity
SEA	Alaska	RPAT 16R	Improved capacity
CLE	Continental	RPAT 6L/24R	Improved capacity

Subsequent to the successful implementation of the special procedures in the two tables above, the FAA is expected to convert them to public procedures where appropriate for wider use at those airports.



Priorities for Public RNP Implementation

Three levels or tiers of priorities are defined for RNP SAAAR implementation. The first priority tier consists of sites and projects that achieve high benefit from a NAS-wide capacity standpoint for a relatively low "cost". These sites leverage existing equipage or rapid equipage growth potential, and focus on sites with identified needs for capacity. Tier 1 also achieves local access and risk management benefits for a few targeted sites. The first tier includes sites that are targeted by the RNP SAAAR lead operators and are included in FAA's Operational Evolution Plan (OEP) Top 35 airports list.

Airports	Characteristics
Tier 1	• **Urgent capacity needs, with national impact** • **Converting *specials* to public procedures** • **Risk mitigation cases**
Tier 2	• **Regional capacity impact** • **Access and risk mitigation enhancement**
Tier 3	• **Predominantly future airspace de-confliction** • **Single runway access and risk mitigation**

Tier 1 Priorities
The first priority tier of sites is detailed below, showing the airport, the RNP SAAAR project, the application, and an indication of whether the site is first priority due to NAS-wide capacity effects, and/or local access and risk management (in some cases as a secondary effect).

Tier 1 Sites and Projects

Airports	Tier 1 Projects	Applications	NAS-Wide Capacity	Access, Risk
2004/2005 Specials	***Conversion to Public, where appropriate***	**All**	**X**	**X**
ATL	***9R/10 and 27L/28, 4200' spacing (RNP SAAAR to 10/28)***	**RPAT (future RPA with RNP/ILS)**	**X**	**x**
SEA	***16L/16R (future) 2500' spacing (RNP SAAAR to 16R future)***	**RPAT (future RPA with RNP-0.1 both sides)**	**X**	**x**
ORD	***9L/9R/4R (RNP SAAAR to 4R)***	**Parallels with SCIAs**	**X**	**x**
DFW	***13R/17C/17L/18R 31R/35C/35R/36L (RNP SAAAR to 13R, 31R)***	**Parallels with SCIAs**	**X**	**x**
EWR	***4L/R and 22L/R***	**RPAT**	**X**	**x**
DTW	***22R/22, 3800' spacing 21R/21L, 2700' spacing***	**RPAT (RNP-ILS)**	**X**	**x**
LGA	***4***	**De-confliction**	**X**	**x**
JFK	***4L/4R, 3000' spacing***	**RPAT (future RPA)**	**X**	**x**
PHL	***27L/R***	**RPAT**	**X**	**x**
PDX	***10L/10R, 3100' spacing***	**RPAT (future RPA)**	**X**	**x**

IAH	***26R/26L/27 and 8R/8L/9***	**Parallels (ILS Backup)**	**X**	
IAD	***12, 19L, 19R Parallels with SCIAs (RNP SAAAR to 12)***	**SCIA and De-confliction**	**X**	
LGB	***7R***	**Single Runway (ILS Backup) and De-confliction**	**x**	**x**
EGE	***25***	**Single Runway**		**X**
ASE	***15***	**Single Runway**		**X**
JAC	***1/19***	**Single Runway**		**X**

Tier 1 Sites and Projects (concluded)

Tier 2 Priorities

The second tier of sites and projects accomplish local capacity benefit and target the remaining airports in the OEP Top 35 and many of the airports in the top 100 from the Airspace Capacity Enhancement (ACE) Plan. This tier of sites and projects is provided in Table 2. These sites have a need for access and safety improvements as well, but do not exhibit as high a need as tier 1 sites, nor do they have the growth rate of equipage needed to achieve benefits in as rapid a time-frame as tier 1 sites. In addition, many of these sites present more challenges from an environmental standpoint; therefore, their "cost" of implementation would tend to be higher. Since the tier 2 sites are not as high priority as tier 1 sites, we would expect their implementation to follow tier 1 implementations. The priority tier 2 sites follow.

Tier 2 Sites and Projects

Airports	Tier 2 Projects	Applications	Local Capacity	Access, Safety
LAX	***7L/R, 25L/R***	**ILS Backup**	**x**	
STL	***12R/12***	**RPAT or RPA**	**x**	
CLE	***24L/R, 6L/R***	**RPAT**	**X**	**x**
BOS	***4R/L***	**RPAT**	**X**	**x**

BWI	***33L (TBD)***	**De-confliction**	**x**	**x**
MSP	***35***	**SCIA**	**X**	
DCA	***1***	**De-confliction**	**X**	**X**
LAS	***25R/L, 19R/L, 7R/L, 1R/L***	**RPAT (limited wx application)**	**X**	
SLC	***16R/L, 17***	**RPAT**	**X**	**X**
OAK	***27R, 27L, 11, 29, 9L, 9R***	**Single runway and De-confliction**	**X**	
TPA	***18L (TBD)***	**Single runway**		**X**
SJC	***30L, 30R, 12R, 12L***	**Single runway and De-confliction**	**X**	**x**
ONT	***8/26 (TBD)***	**Single runway De-confliction**		**X**
BUR	***8***	**Single runway De-confliction**	**X**	
HNL	***8L***	**Single runway**	**X**	
MIA	***8, 26, 30 or TBD***	**Single runway (no existing PA) or De-confliction**	**X**	**x**
FLL	***9s, 13 or 27s (TBD)***	**Single runway**		**X**
MEM	***18s***	**RPA or RPAT**	**X**	**x**
TEB	***TBD***	**De-confliction**	**X**	**X**
IAH	***26L/R, 8L and 9***	**Single runway**	**x**	**X**
SFO	***10R***	**Single runway**	**x**	**X**
GUC	***6/24***	**Single runway**		**X**
HDN	***10/28***	**Single runway**		**X**
EAT	***12/30***	**Single runway**		**X**
OTH	***4/22***	**Single runway**		**X**

Tier 2 Sites and Projects (concluded)

Tier 3 Priorities
The third tier of sites and projects are at less busy airports with single runway benefits that provide local access and safety benefits. These sites are targeted for implementation at least 8-10 years out, to align with capacity needs several years into the future and lower equipage growth rates. The driving benefit for operators at these sites is improved predictability for operations at these sites during IMC. This is exemplified by an analysis of the height above threshold (HAT) that is achieved by applying the RNP SAAAR obstruction clearance areas. The HAT values determined by modeling LNAV/VNAV approaches are compared to the potential HAT values achievable with RNP SAAAR criteria. These access values are consistently better and therefore result in access benefits to these single runways.

A secondary benefit is reduced pilot training/continued qualification and risk management costs for continued operations at these sites. These are reduced costs through eliminating visual maneuvering to land, use of constant descent (fully-managed) approaches and improved guidance to runways in obstacle-rich environments. The sites that would be included in this priority tier are among those listed below.

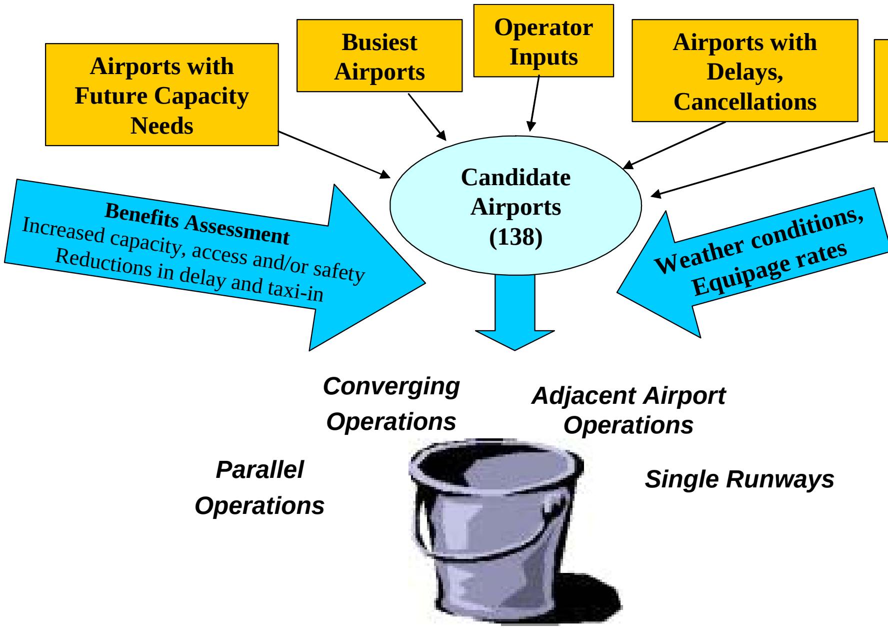
IMPORTANT NOTE: Analysis is still needed to determine if RNP SAAAR is required to improve minimums below improvements that may be achieved with RNP (non-SAAAR) or RNAV criteria that may be defined in the coming years.

Priority Tier 3 candidate sites therefore may include the following:

- **Access sites: ABQ, BDL, BOI, BNA, CLT, CVG, DAL, DAY, FCA, GEG, HOU, HPN, IND, MCI, MCO, MSY, PBI, PDK, PHX, PIT, PRC, RDU, SAN, SAT, SDF, SDL, SJU**
- **Risk mitigation sites: BIH (Bishop serving Mammoth Lakes, CA), BTM (Butte, MT), COD (Cody, WY), DRO (Durango, CO), LEB (Lebanon, NH), LMT (Klamath Falls, OR), RIL (Rifle, CO)**

3. Method for Site Selection and Prioritization

The assessment of airport candidacy for RNP SAAAR procedures included a large number of airports (138 in total, see Appendix A for complete list) and was based on many factors: airport operations and runway layouts, cost of delays and cancellations due to IMC weather conditions at each airport, the manner in which delays at that airport propagate across the NAS, the ability of RNP SAAAR to mitigate delays and cancellations, RNP SAAAR equipage rates and probability of growth, airspace constraints, obstructions/terrain, the sufficiency of existing approach minimums, environmental constraints, and operator needs for improved access or safety. These factors were given weights and assessed for each of the airports for which detailed data was available.



Some of these factors had well-defined values and some were not well-defined. For example, the current equipage at an airport is fairly well-known and accepted. However, the equipage at an airport in the future (e.g., 2015) must be forecast and the confidence in this value would be much lower. Another factor of low confidence is the minimum conditions for a particular RNP SAAAR procedure. The exact minimum conditions for ceiling and visibility for the procedure are still in doubt, but a small range of values might be accepted.

To handle these low confidence parameters, a sensitivity analysis was performed to see how various values would affect the ranking of sites. All parameters that had relatively low confidence were set at multiple values during the analysis to determine the impact of the parameters. For example, the future equipage at Atlanta could be set to 80%, 90%, and 100%. The result of the sensitivity analysis was that the ranking of airports did not change significantly. Therefore, despite low confidence in some of the parameter values, the assessment method still allowed for high confidence in the final rankings.

More detail on the data, analysis, tools, and metrics is available upon request to the PARC.

4. Implementation Steps and Summary

The air transportation system capacity, efficiency and safety challenges facing the operators in the near term and mid term underscore the importance and urgency of expediting implementation of RNP procedures to accrue benefits to NAS operators and users. The FAA and industry have collaboratively identified the RNP applications and determined the initial airports at which these applications will result in benefits. A twopronged strategy was adopted to achieve (1) early success and lessons learned through implementation of special proprietary procedures by lead operators, and (2) full implementation of benefits-driven public RNP procedures in order to realize the maximum potential of these applications and benefits. [3]

Public RNP SAAAR Procedure Implementation: Issues and Challenges

The *Roadmap* identifies three time fames for implementation of procedures: near term (2003-2006), mid term (2007-2012), and far term (2013-2020). The early special implementation of RNP procedures, lessons learned and the validation of the RNP criteria discussed above are expected to be completed in the near term time frame. The three-tier list of applications and airports for public RNP instrument approaches are intended to begin at the end of the near term and be expedited through the mid-term, as outlined in the *Roadmap*. In order to ensure the successful implementation of these procedures and the realization of the benefits to the operators and service provider, several key implementation issues must be address. The FAA and the aviation community have identified top priority issues to be addressed in the near term in order to streamline the successful implementation of these procedures in the mid-term.

Mixed Equipage Considerations

RNP SAAAR is admittedly a high end type of procedure that requires sophisticated avionics capabilities, aircraft evaluations and operator authorizations. Required capabilities for RNP SAAAR approaches may include for example satellite navigation, redundant flight management computing, real-time containment with RNP alerting at RNP-0.3 or better, radius-to-fix path terminators, vertical navigation to a decision altitude, and other special equipment, training and approvals. The current level of aircraft equipage is quite varied, even across the sites we are pursuing for RNP SAAAR "specials" this year and next year:

- Portland, Oregon estimated at 40-50% (mainly Horizon and Alaska Airlines which are quickly becoming RNP SAAAR eligible)
- Houston and Newark estimated to be 30-40% (mainly Continental Airlines which is also quickly becoming RNP SAAAR eligible)
- Chicago's Midway, Washington Reagan and New York's Kennedy estimated to be 20-30% (mixed carriers, almost entirely scheduled operations)
- Tucson, Palm Springs and Philadelphia at 10-20% (mixed types of aircraft and operations ranging from scheduled air carrier with high equipage, to non-scheduled and unequipped general aviation).

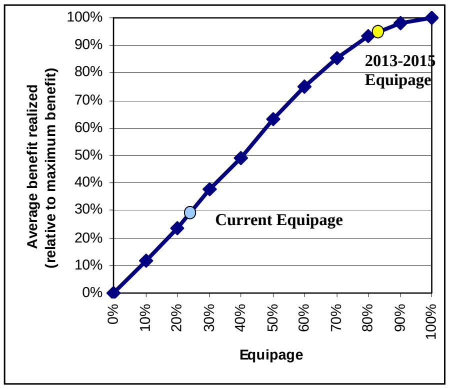
From this short list, we can see that the current level of equipage and the rate of growth for RNP SAAAR eligible flights on a site specific basis depend on the lead carrier, the mixture of carriers, aircraft, and scheduled/unscheduled operations. The best candidates for RNP SAAAR equipage are sites with lead carriers nearing eligibility and comprising

[3] While specific operators will continue to benefit from *special* procedure implementations on an as-needed basis for specific operational mitigations needed at certain airports, the RNP applications at airports identified in this report are intended for public procedure implementation.

the majority of operations at the site. Overall, the percentage of flights Part 121 aircraft nominally equipped for RNP SAAAR approach operations is approximately 1/3 of the aircraft. This number is growing through the process of fleet replacement at a conservative rate of 4-5% of the fleet size per year. This growth rate assumes that by about 2010 half of the fleet would be RNP SAAAR equipped, and then by 2017-2020, all Part 121 aircraft would be RNP SAAAR equipped.

The type of RNP SAAAR procedure being applied at a site is also a consideration in mixed equipage operations. It is clear that the operating concepts for RNP SAAAR approaches must take into account flights that are not participating, either through segregation of flows and runway usage or through integrated flows with mixed equipage. In some cases (e.g., RPAT with ILS to one runway and RNP to the other), the concepts are adapted to mixed equipage environments, while other concepts (e.g., RPA with RNP to both parallel runways) are not.

Simulated RPAT Equipage-Benefit Ratio
• Partial equipage relates to partial procedure benefit
• Actual benefit depends on likelihood of having an equipped flight available to take advantage of extra capacity



The benefit that can be achieved with mixed equipage will be maximized if the concept of implementation takes into account a method for efficiently managing unequipped, non-participating flights. The worst case scenario for unequipped operators would be to "hold" or delay until all equipped, participating flights have arrived. This, however, would be a strong motivator for equipping and would accelerate the transition!

Longer-term Concept and Benefits

The longer-term concept of implementation for approaches is simplified from the manner in which procedures are developed, trained for, and flown today. The future concept allows for perhaps just three basic types of instrument approaches: ILS (or ILS-like), RNP SAAAR, and basic RNAV. This eliminates all other approach types. It is expected that the majority (if not all) of non-ILS procedures will be flown with airplane lateral and vertical navigation functionality. There are several key advantages of this type of long-term implementation scheme. With this implementation, the simulation training resources may be reduced due to the shorter periods dedicated to instrument approach training. Flight standardization of pilot operating procedures will be simplified due to the fewer differences in approach operations. Eliminating (or at least minimizing) the use of non- precision approaches will improve safety. Missed approaches will be flown more safely with lateral and vertical guidance where and when needed for mitigating terrain and obstructions.

Conclusions

The FAA and industry are committed to implement the commitments of RNP instrument approach procedures outlined in the Roadmap. The Roadmap has articulated a strategy for early successes in the near term with implementation of special RNP procedures followed by full implementation of public RNP instrument approach procedures where beneficial. The early implementation of specials are expected to result in invaluable lessons learned that will enable the FAA and industry to develop RNP criteria in a manner that will enable wide-scale utilization of these procedures by operators at the nation's airports in need of capacity, efficiency and safety improvements.

The FACT report articulates which regions and airports in the United States will be in need of capacity and efficiency in the near term as well as in the 2013 and 2020 time frames. The FACT report points out that the regions and airports in need of capacity will expand beyond the top 35 OEP airports into additional airports near or adjacent to many of the current hubs. The analysis of how and where RNP instrument approach procedures can be helpful is consistent with the FACT forecasts. Therefore, in order to meet these capacity and efficiency needs in the time frames when they will be needed, it is imperative to implement the RNP procedures expeditiously.

Appendix A
List of Sites Considered for RNP SAAAR

ABQ Albuquerque International Airport
ALB Albany County Airport
ANC Ted Stevens Anchorage International Airport
ASE Aspen-Pitkin County Airport/Sardy Field
ATL Hartsfield Atlanta International Airport
AUS Austin-Bergstrom International Airport
AVL Asheville Regional Airport
BDL Bradley International Airport
BGM Greater Birmingham Airport/Edwin ALink Field
BHM Birmingham Airport
BIH Bishop, CA Airport
BKW Raleigh County Memorial Airport
BLF Mercer County Airport
BNA Nashville International Airport
BOI Boise Air Terminal
BOS Boston Logan International Airport
BTM Bert Mooney Airport
BTV Burlington International Airport
BUF Greater Buffalo International Airport
BUR Burbank Glendale Pasadena Airport
BWI Baltimore Washington International Airport
CBE Greater Cumberland Regional Airport
CHS Charleston International Airport
CLE Cleveland Hopkins International Airport
CLT Charlotte/Douglas International Airport
CMH Port Columbus International Airport
COD Yellowstone Regional Airport
COS Colorado Springs Municipal Airport
CRW Yeager Airport
CVG Greater Cincinnati International Airport
DAL Dallas-Love Field
DAY Dayton International Airport
DCA Ronald Reagan National Airport
DEN Denver International Airport
DFW Dallas-Fort Worth International Airport
DRO Durango-La Plata County Airport
DSM Des Moines International Airport
DTW Detroit Metropolitan Wayne County Airport
EAT Pangborn Memorial Airport
EEN Dillant-Hopkins Airport
EGE Eagle County Regional Airport
ELM Elmira/Corning Regional Airport
ELP El Paso International Airport
EWR Newark Liberty International Airport
FCA Kalispell, MT Airport
FLG Flagstaff Pulliam Airport
FLL Fort Lauderdale Hollywood International Airport
GEG Spokane International Airport

GRR	Gerald R. Ford International Airport
GSO	Greensboro Piedmont Triad International Airport
GSP	Greenville-Spartanburg International
GUC	Gunnison-Crested Butte Regional Airport
GUM	Guam International Airport
HDN	Yampa Valley Airport
HNL	Honolulu International Airport
HOU	Houston William P. Hobby Airport
HSP	Ingalls Field Airport
HTS	Tri-State Airport/Milton J. Ferguson Field
IAD	Washington Dulles International Airport
IAH	George Bush International Airport
IFP	Laughlin/Bullhead Internati onal Airport
IND	Indianapolis International Airport
ISP	Islip Long Island MacArthur Airport
ITO	Hilo International Airport
JAC	Jackson Hole Airport
JAN	Jackson International Airport
JAX	Jacksonville International Airport
JFK	New York John F. Kennedy International Airport
KOA	Kona International Airport at Keahole
LAS	Las Vegas McCarran International Airport
LAX	Los Angeles International Airport
LEB	Lebanon Municipal Airport
LGA	New York LaGuardia Airport
LGB	Long Beach Aiport
LIH	Lihue Airport
LIT	Little Rock Adams Field
LMT	Klamath Falls Airport
MCI	Kansas City International Airport
MCO	Orlando International Airport
MDW	Chicago Midway Airport
MEM	Memphis International Airport
MHT	Manchester Airport
MIA	Miami International Airport
MKE	Milwaukee General Mitchell International Airport
MSN	Madison/Dane County Regional Airport
MSO	Missoula International Airport
MSP	Minneapolis-St. Paul International Airport
MSY	Louis Armstrong New Orleans International Airport
MYR	Myrtle Beach International Airport
OAK	Metropolitan Oakland International Airport
OGG	Kahului Airport
OKC	Oklahoma City Will Rogers World Airport
OMA	Omaha Eppley Airfield
ONT	Ontario International Airport
ORD	Chicago O Hare International Airport

ORF Norfolk International Airport
OTH North Bend Municipal Airport
PBI Palm Beach International Airport
PDK Atlanta Dekalb-Peachtree Airport
PDX Portland International Airport
PHL Philadelphia International Airport
PHX Phoenix Sky Harbor International Airport
PIT Greater Pittsburgh International Airport
PSP Palm Springs Regional Airport
PVD T. F. Green Airport
PWM Portland International Jetport
RDU Raliegh-Durham International Airport
RIC Richmond International Airport
RIL Garfield County regional Airport
RNO Reno Tahoe International Airport
ROA Roanoke Regional Airport/Woodrum Field
ROC Greater Rochester International Airport
RSW Fort Meyers Southwest Florida Regional Airport
SAN San Diego International Lindberg Field
SAT San Antonio International Airport
SAV Savannah International Airport
SDF Louisville International Airport
SDL Scottsdale Airportt
SEA Seattle-Tacoma International Airport
SFB Orlando Sanford Airport

SFO San Francisco International Airport
SHD Shenandoah Valley Regional Airport
SJC Norman Y. Mineta San José International Airpor
SJU San Juan Luis Muñoz Marín International Airpor
SLC Salt Lake City International Airport
SLK Adirondack Regional Airport
SMF Sacramento International Airport
SNA John Wayne Airport–Orange County
SRQ Sarasota Bradenton Airport
STL Lambert St. Louis International Airport
SUN Friedman Memorial Airport
SYR Syracuse Hancock International Airport
TEX Telluride Regional Airport
TPA Tampa International Airport
TUL Tulsa International Airport
TUS Tucson International Airport
TVL Lake Tahoe Airport
TYS Knoxville McGhee-Tyson Airport
WYS Yellowstone Airport